

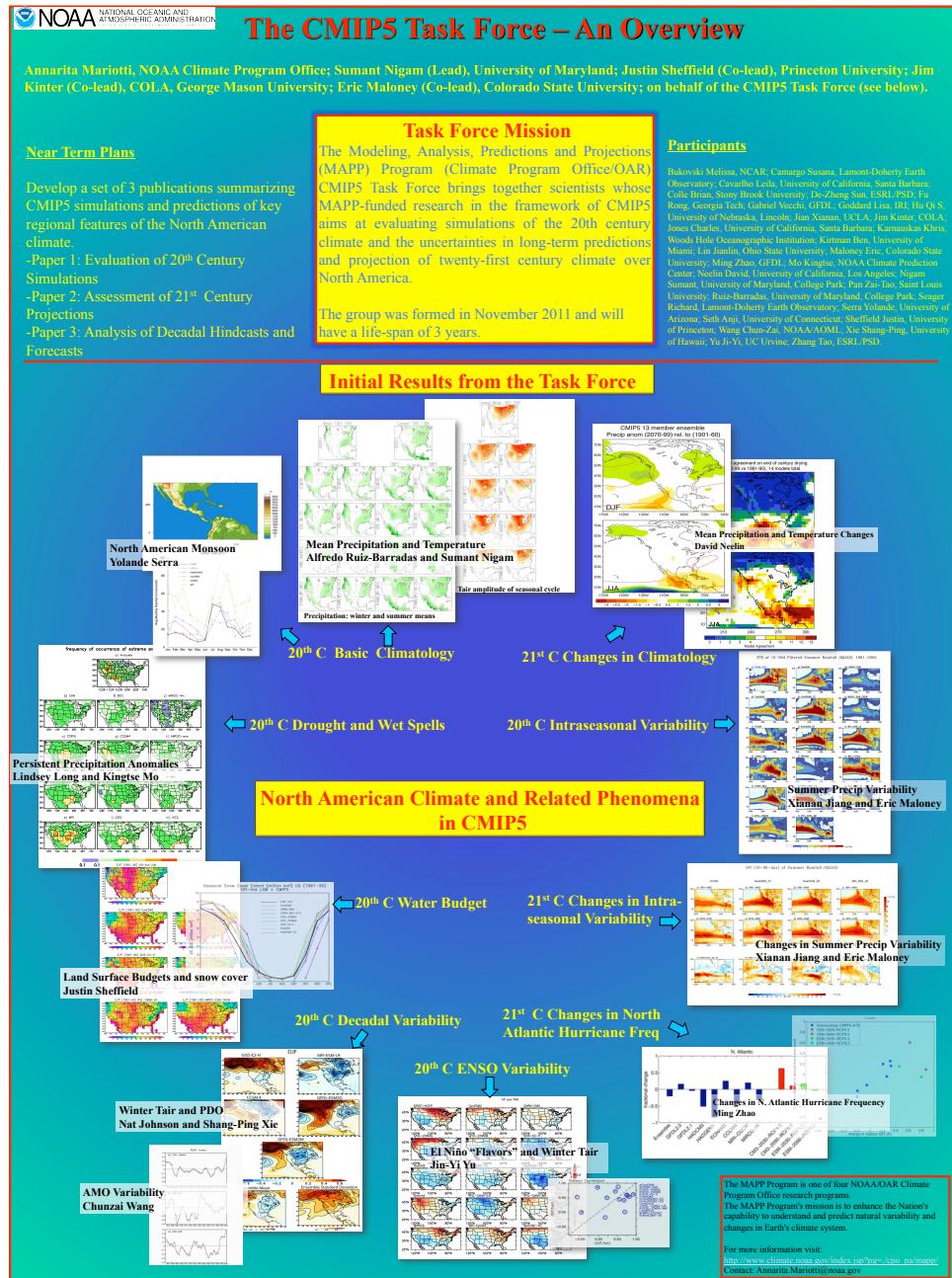
1. Overview of NOAA CMIP5 Task Force Model Evaluations
2. Global and regional drought from CMIP5: Evaluations of contemporary climate simulations and implications for future projections

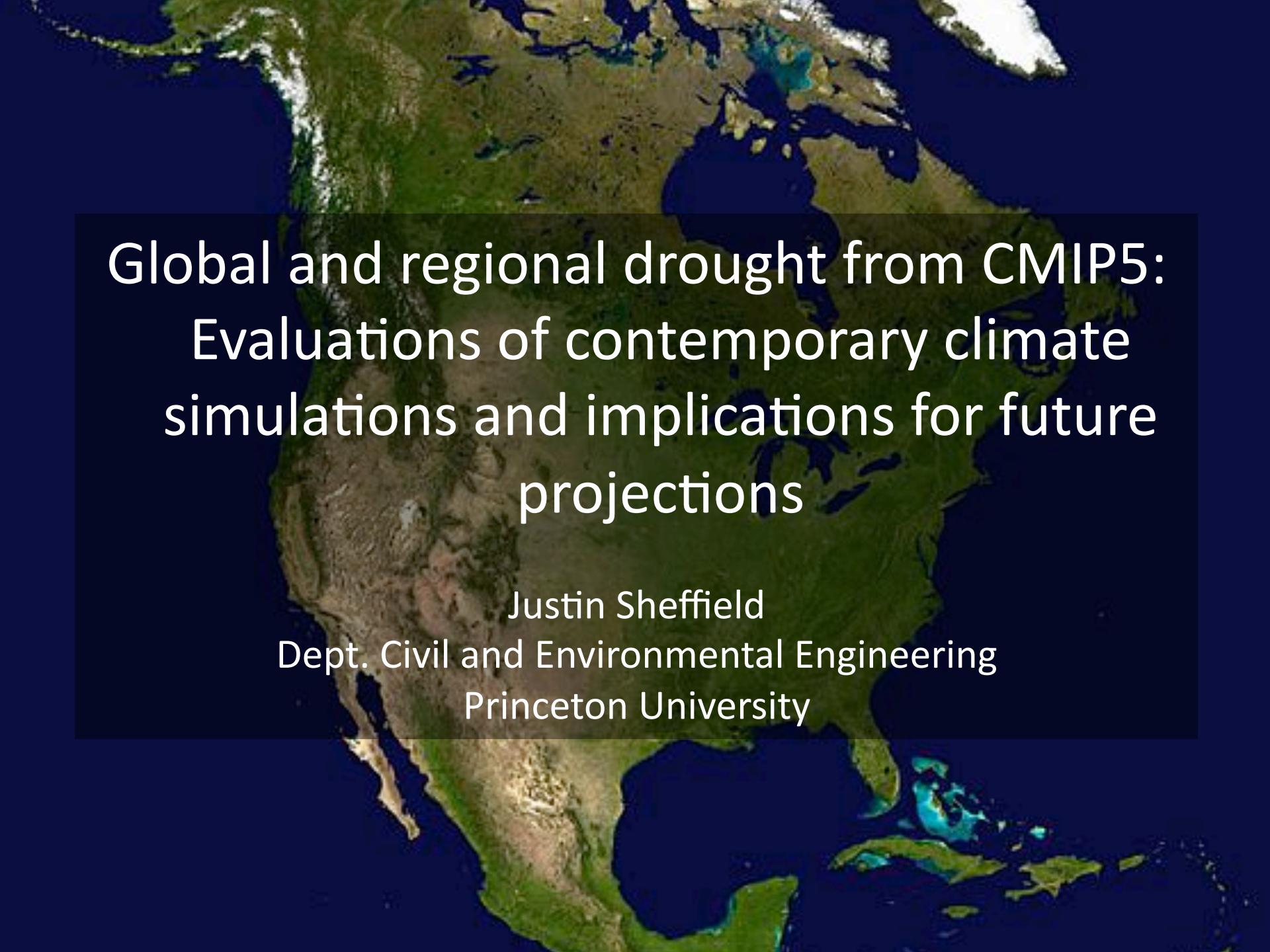
Overview of NOAA CMIP5 Task Force Model Evaluations

- 1. Goal is to evaluate CMIP5 historical simulations and projections/predictions**
- 2. Via three papers to be submitted to a J. Climate special issue on CMIP5 N. America climate**
 - 1. Evaluation of North American 20th Century climate in CMIP5*
 - 2. 21st Century projections of North American climate in CMIP5*
 - 3. Analysis of Decadal Hindcasts and Forecast*

Paper 1 looks at a range of climate features relevant to N. American climate and its impacts:

1. ***Continental climate*** (precipitation, temperature, land/atmosphere water budgets, SSTs, biophysical indicators, persistent dry/wet spells)
 2. ***Regional climate*** (east coast winter storms, northeast precipitation, western water, north American monsoon, Great Plains low level jet/drought, Arctic seas ice, south/southeastern extremes)
 3. ***Intra-seasonal variability*** (PNA, NAO, MJO)
 4. ***East Pacific and Atlantic tropical cyclones***
 5. ***Inter-annual to decadal variability and trends*** (ENSO plus teleconnections, warm/cold event asymmetry, AMO, PDO, warming hole, trends in precipitation, temp).





Global and regional drought from CMIP5: Evaluations of contemporary climate simulations and implications for future projections

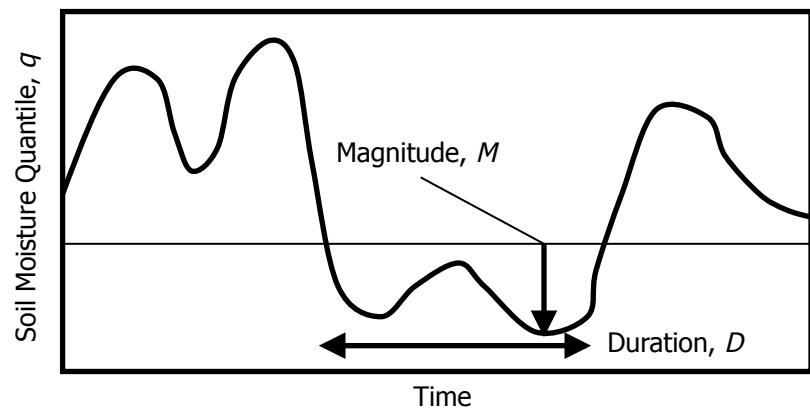
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Background

- Drought causes large impacts to agriculture, water supply, economies and ecosystems.
- Speculation that droughts have increased over the past 30 years and expectation is that droughts will become more frequent and intense in the future.
- Soil moisture is a key variable of the climate system
- Constrains transpiration/photosynthesis, with impacts on the water, energy and biogeochemical cycles.
- Storage for precipitation and radiation anomalies, inducing persistence in the climate system.
- Key player in feedbacks at local to global scales, and plays a major role in climate-change projections.

Approach: Data and Methods

1. Focus on soil moisture and other land components of the terrestrial water cycle
2. Analysis of drought characteristics in CMIP5 models
3. Drought characteristics:
 - Duration
 - Magnitude
 - Severity or Deficit Volume
 - Areal Extent
4. Evaluate against off-line land surface modeling
 - VIC LSM
 - Forced by hybrid obs/reanalysis meteorological data (Sheffield et al. 2006)
5. Diagnose differences in terms of climate variability and soil moisture dynamics



$$\text{Severity, } S = D \times M$$

Extent, A = area in drought

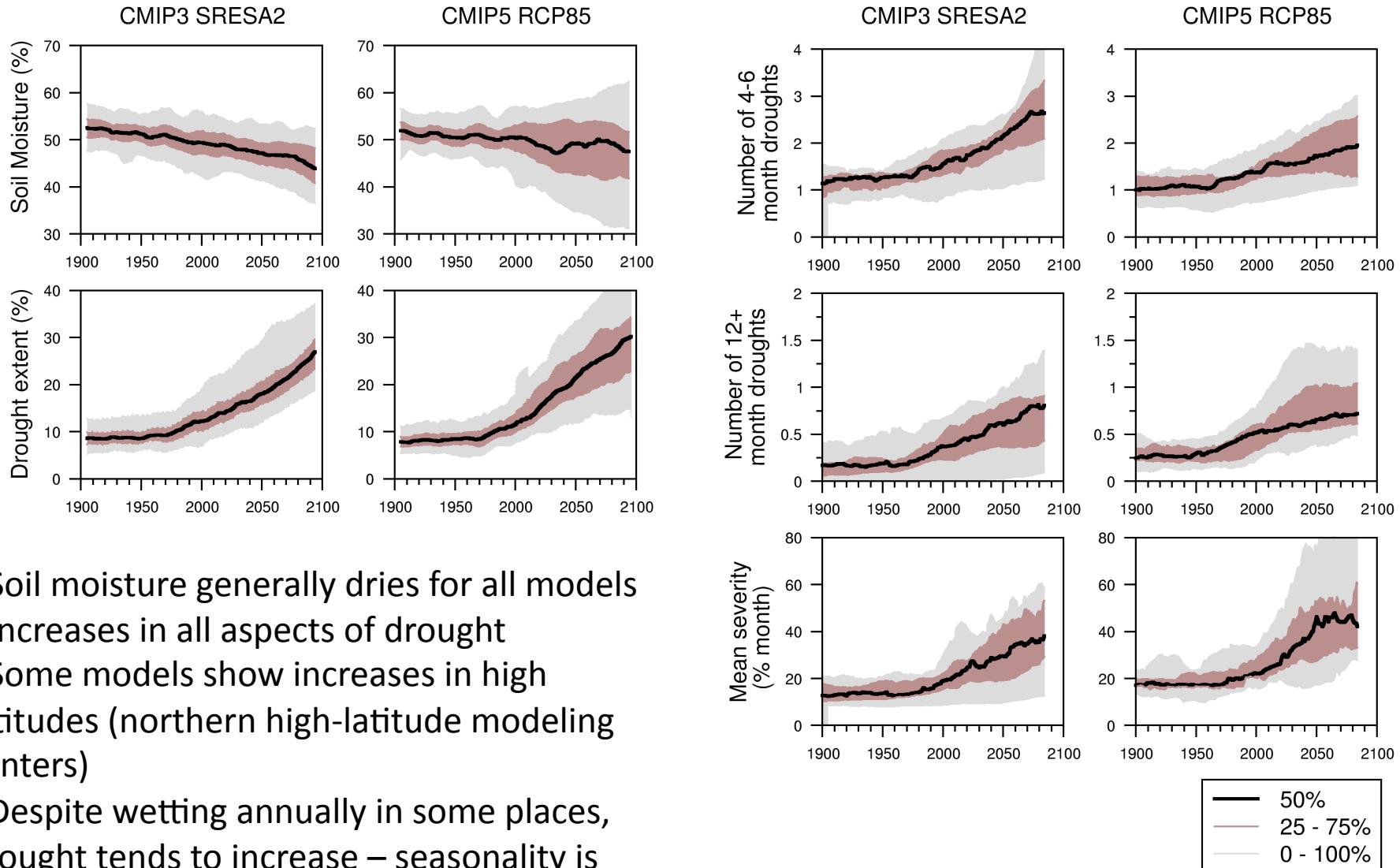
Clim Dyn
DOI 10.1007/s00382-007-0340-z

Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations

Justin Sheffield · Eric F. Wood

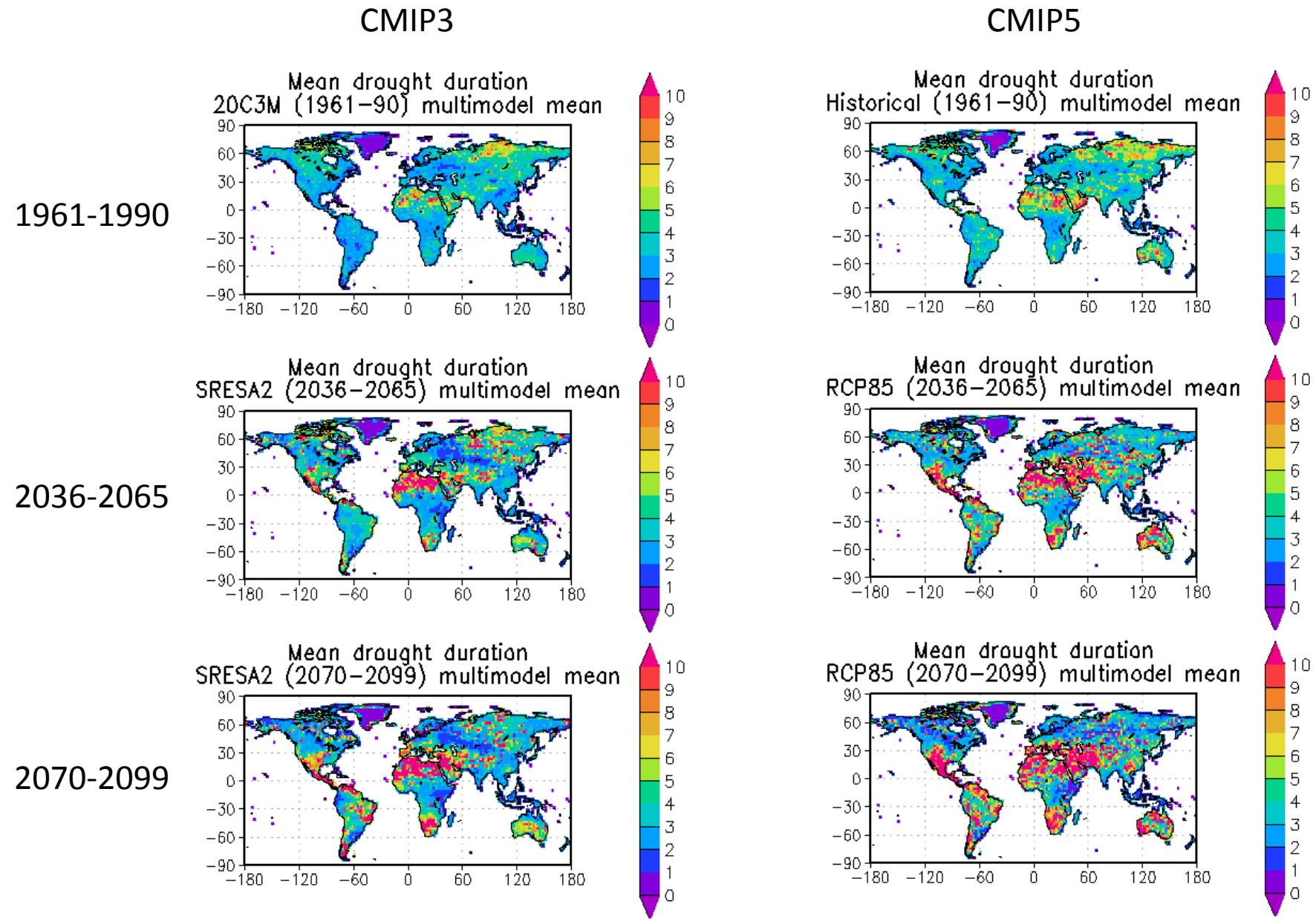
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Future Projections



- Soil moisture generally dries for all models
- Increases in all aspects of drought
- Some models show increases in high latitudes (northern high-latitude modeling centers)
- Despite wetting annually in some places, drought tends to increase – seasonality is important

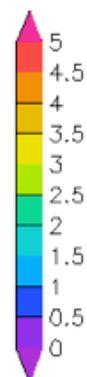
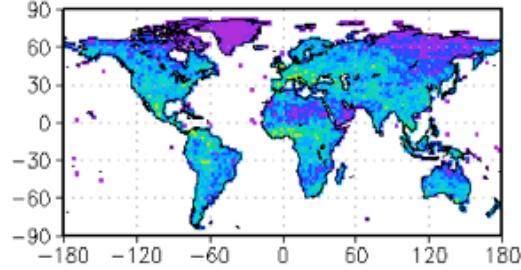
Spatial Patterns of Future Projections of Drought Duration



Spatial Patterns of Future Projections of Short-Term Drought

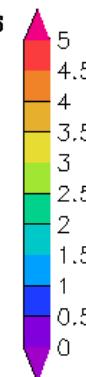
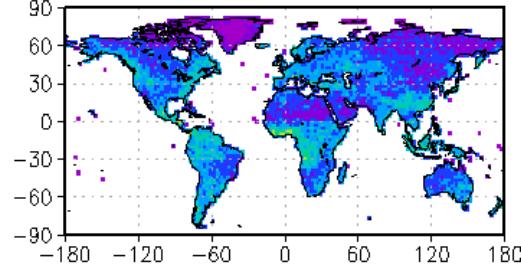
CMIP3

Frequency of 4–6 mo duration droughts
20C3M (1961–90) multimodel mean



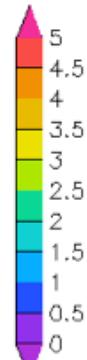
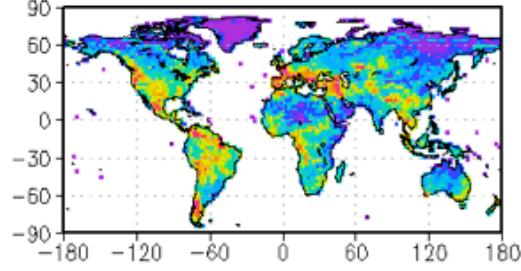
CMIP5

Frequency of 4–6 mo duration droughts
Historical (1961–90) multimodel mean



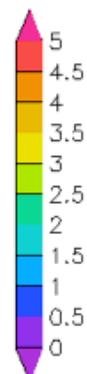
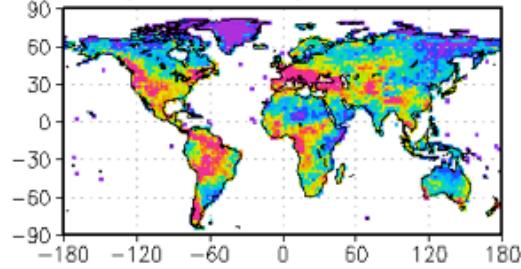
1961–1990

Frequency of 4–6 mo duration droughts
SRESA2 (2036–2065) multimodel mean



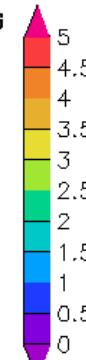
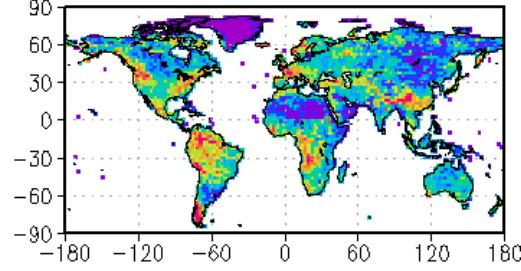
2036–2065

Frequency of 4–6 mo duration droughts
SRESA2 (2070–2099) multimodel mean

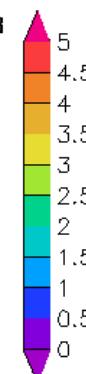
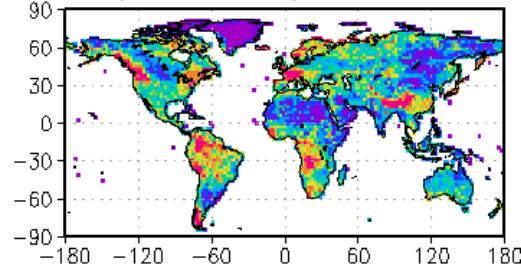


2070–2099

Frequency of 4–6 mo duration droughts
RCP85 (2036–2065) multimodel mean

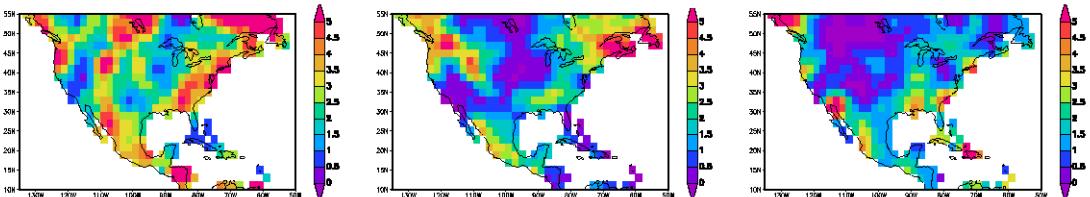


Frequency of 4–6 mo duration droughts
RCP85 (2070–2099) multimodel mean

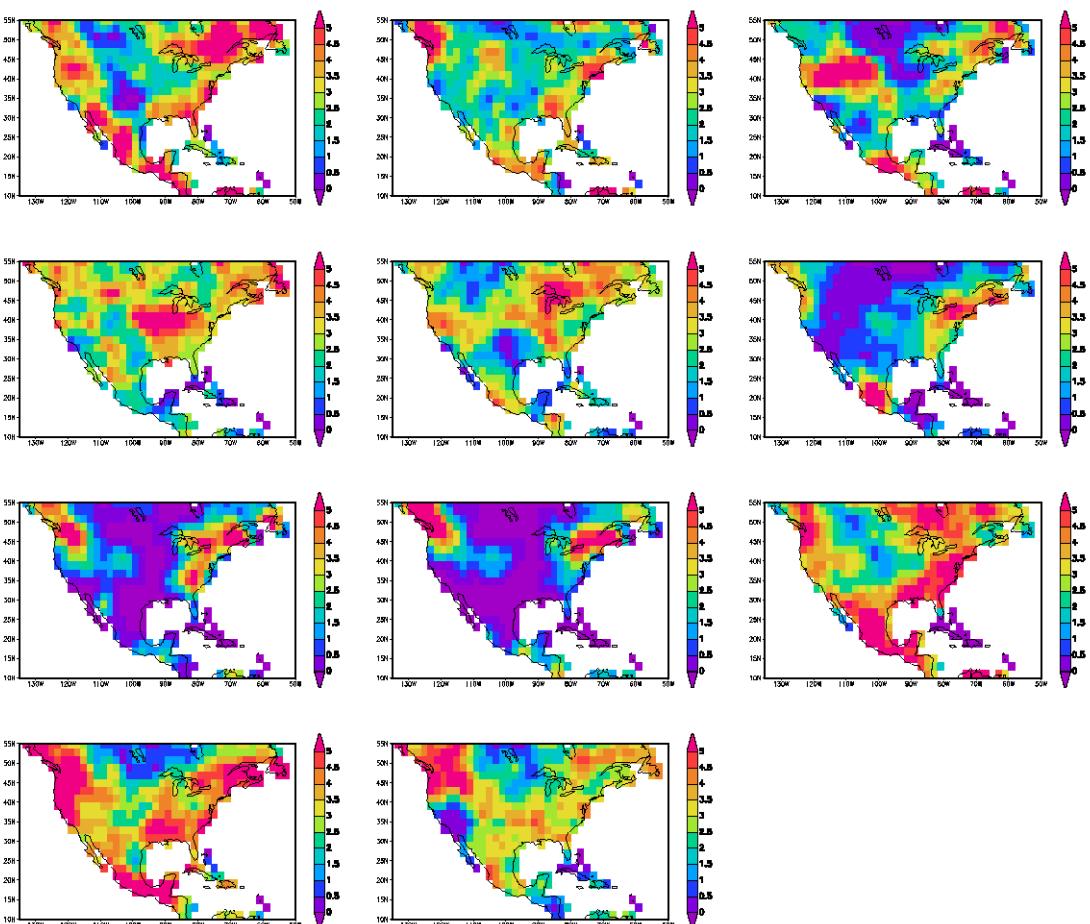
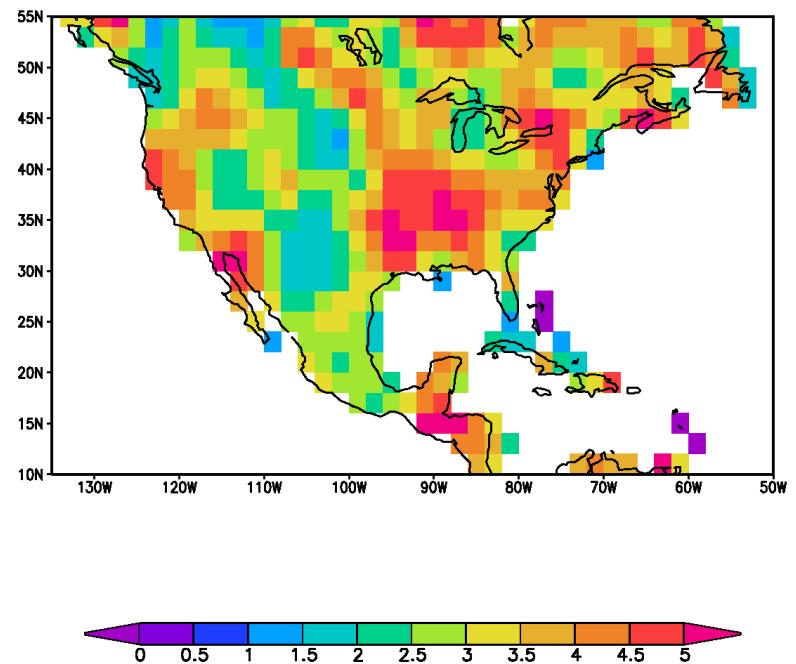


20C Evaluations: Frequency of Short-Term (3-6 month) Drought

CMIP5 Models

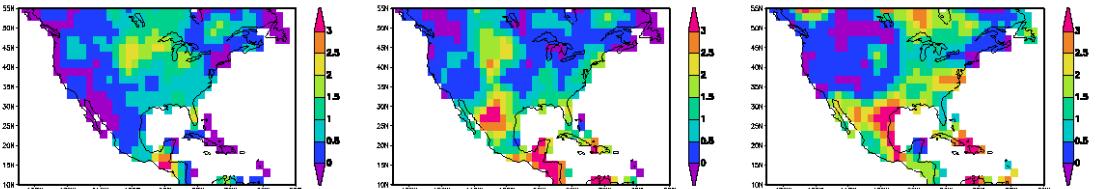


VIC Off-line LSM

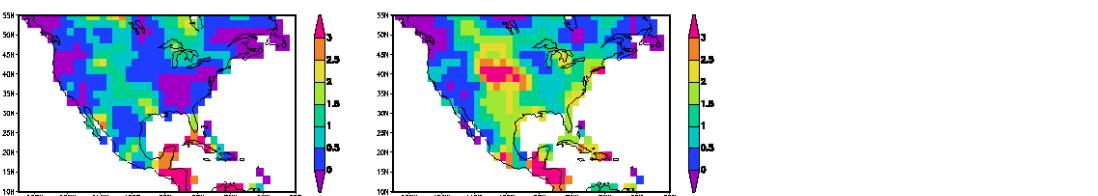
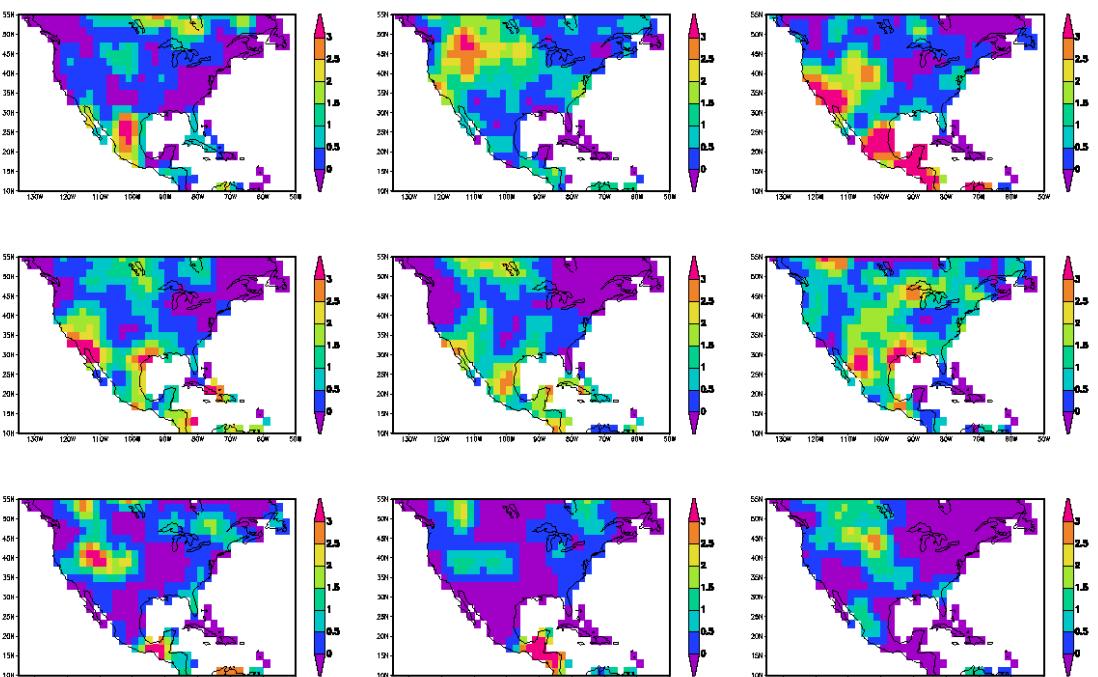
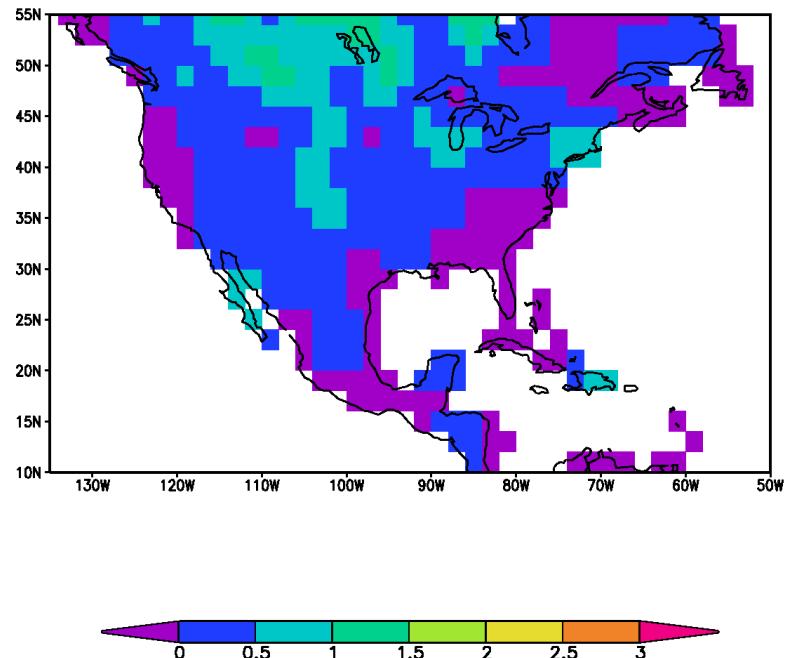


20C Evaluations: Frequency of Long-Term (> 12 months) Drought

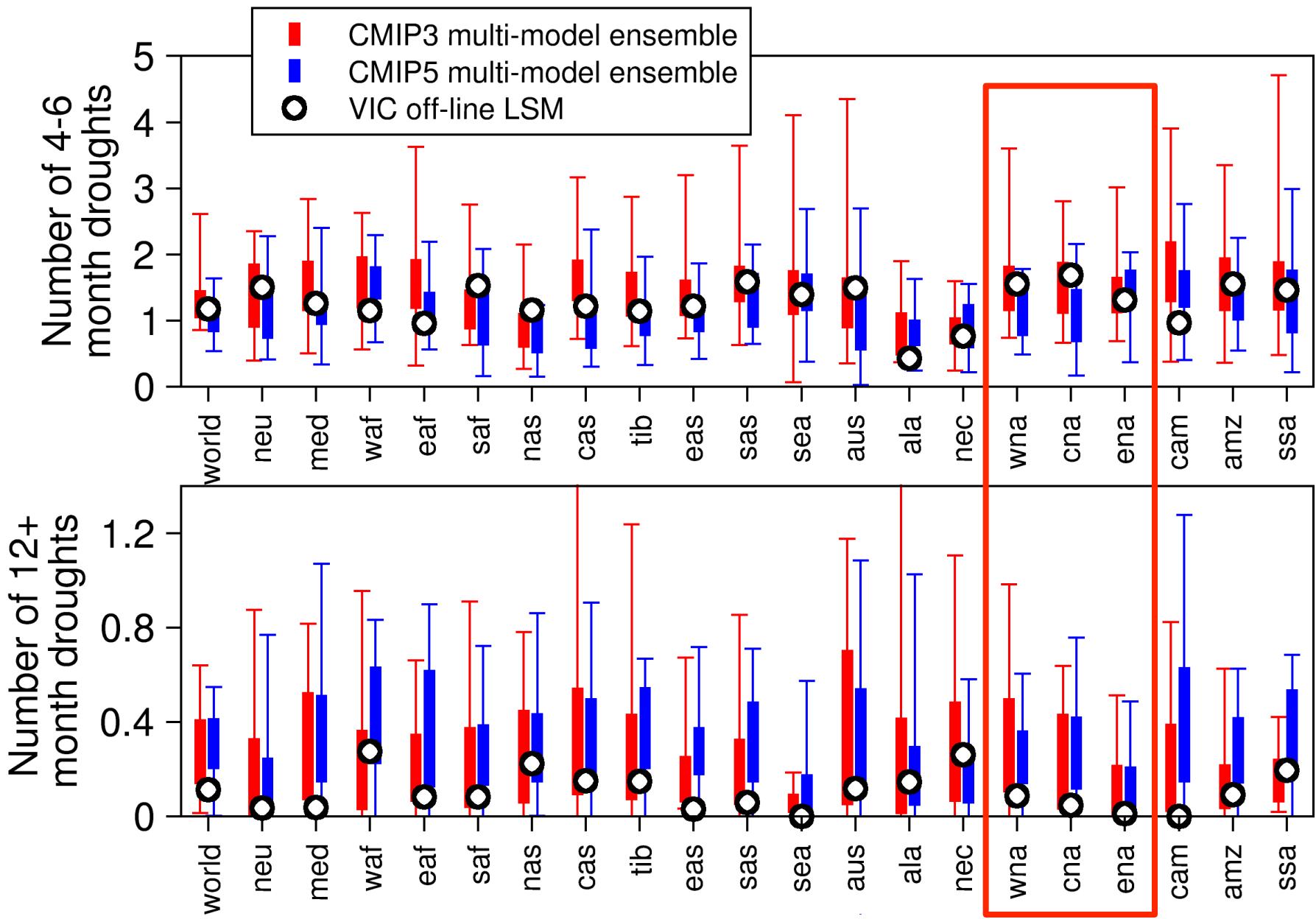
CMIP5 Models



VIC Off-line LSM



Global and Regional Summary of Drought Statistics

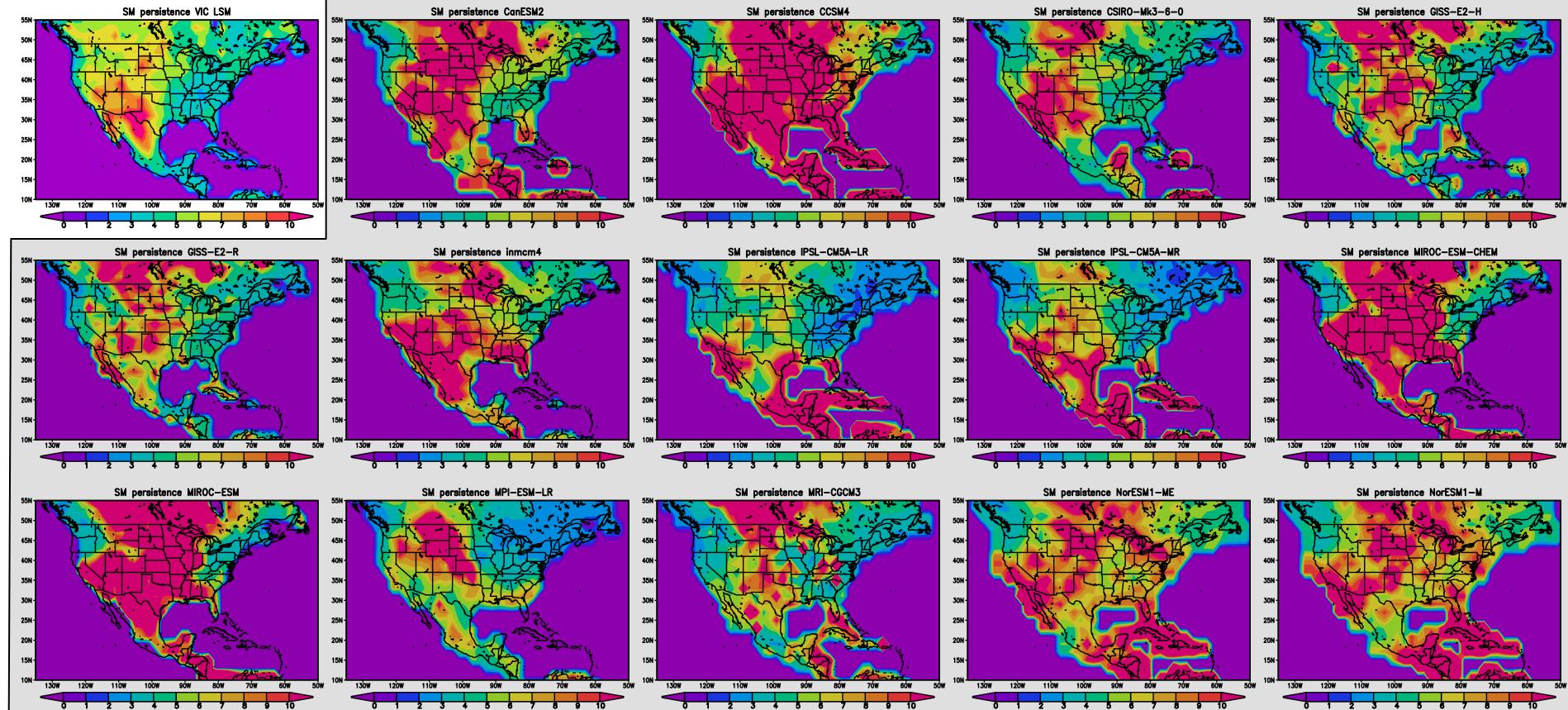


Persistence in Soil Moisture

Persistence is calculated as the average number of months spent in dry anomalies

CMIP5 MODELS

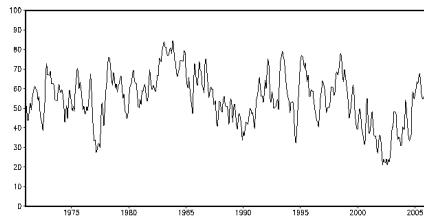
VIC LSM



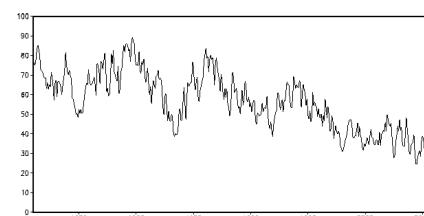
Diagnosing Differences in Soil Moisture Persistence

Western NA

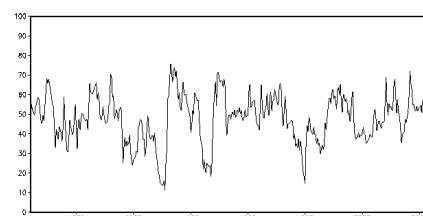
Off-line LSM



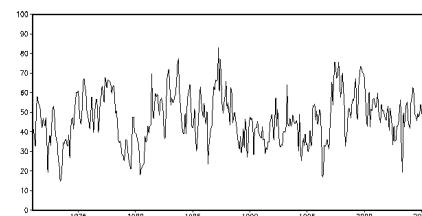
Model 1



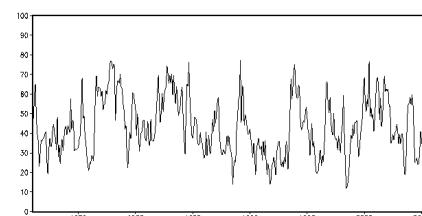
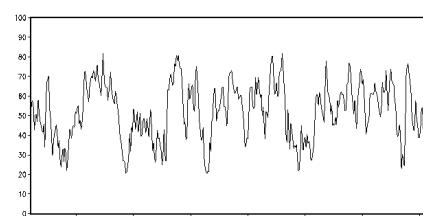
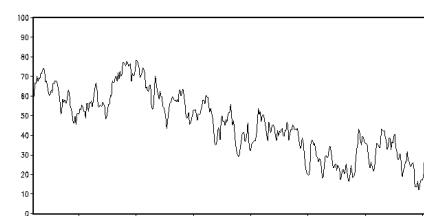
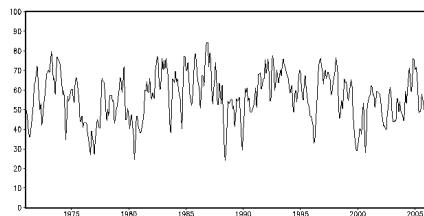
Model 2



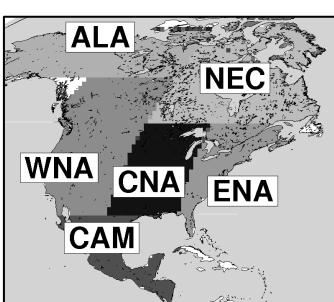
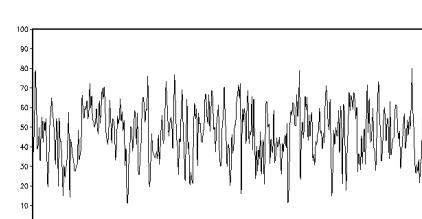
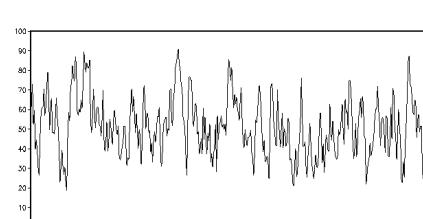
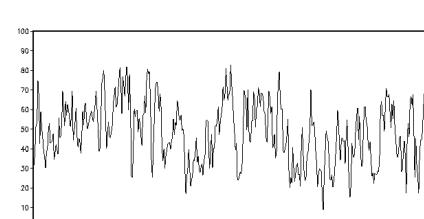
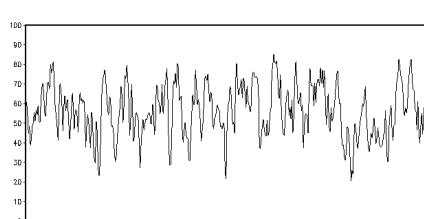
Model 3



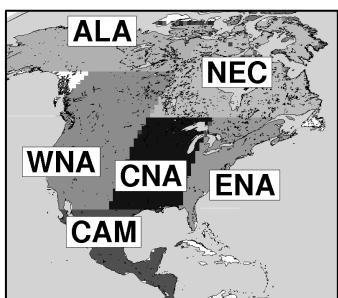
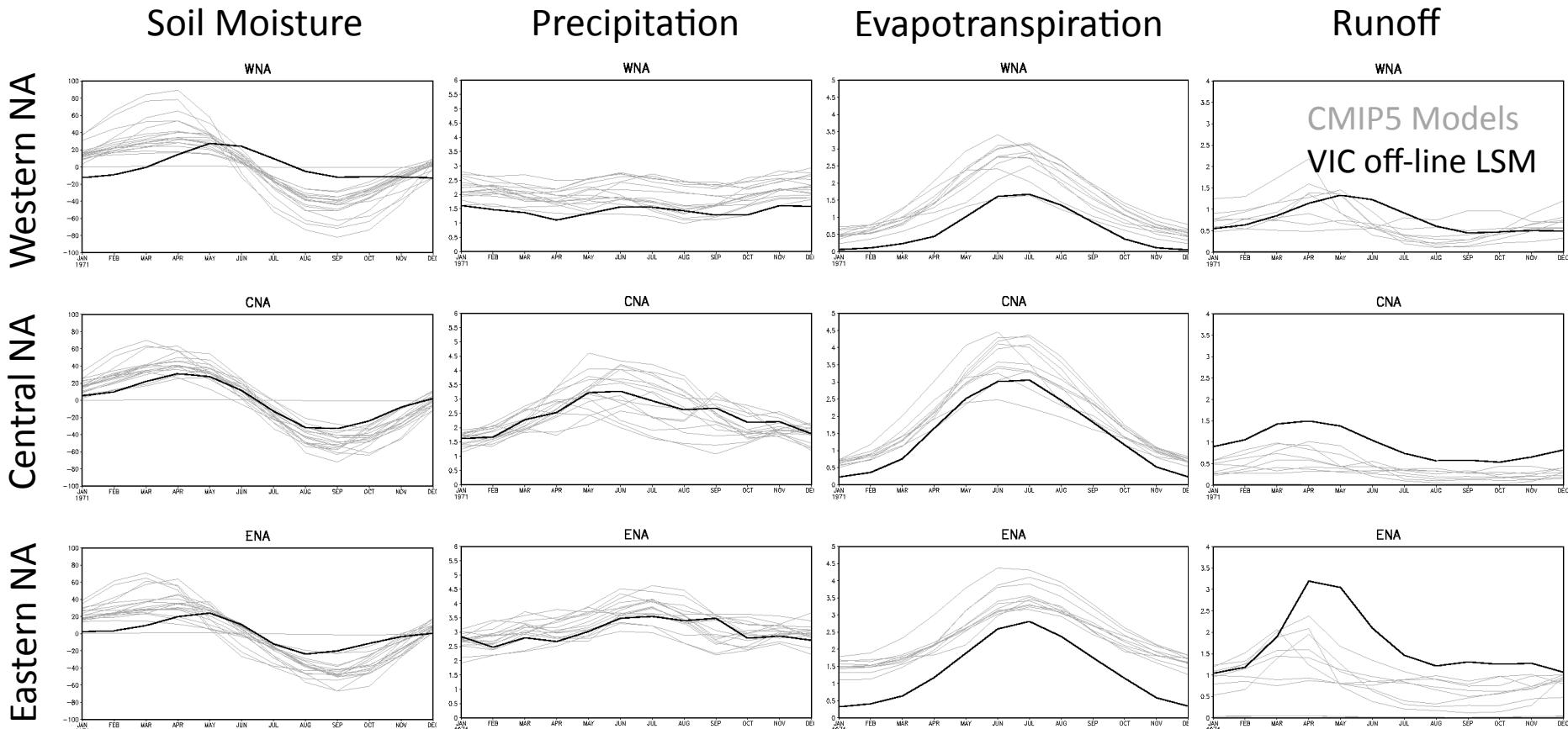
Central NA



Eastern NA

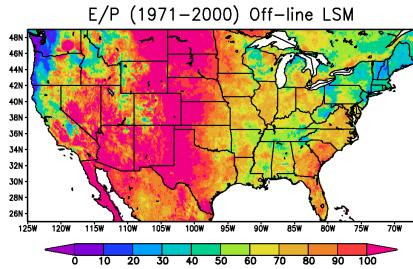


Seasonal Water Budgets for N. American Regions

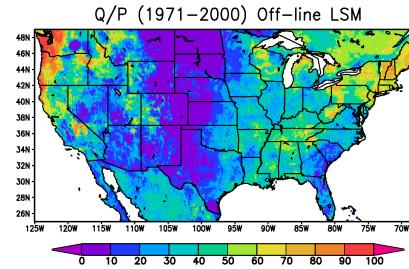


- Soil moisture tends to wet too early in CMIP5 models
- and has larger dynamic range (deeper soils, more P, more E)
- Precipitation is too high in the west
- Evapotranspiration is generally too high, regardless of precip
- Runoff is too low and spring melt peaks too early

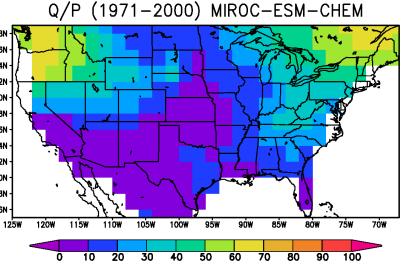
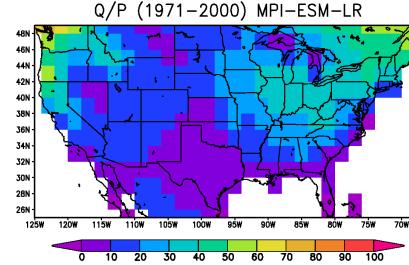
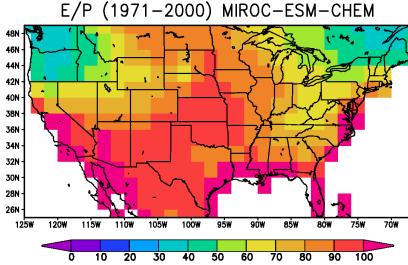
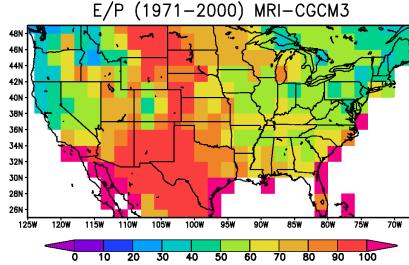
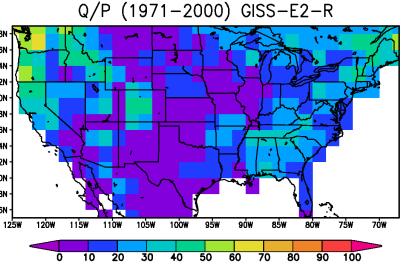
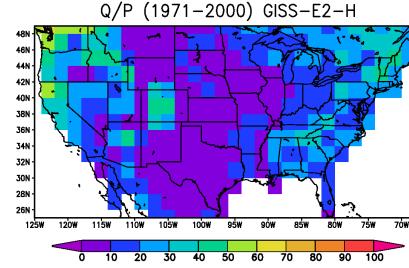
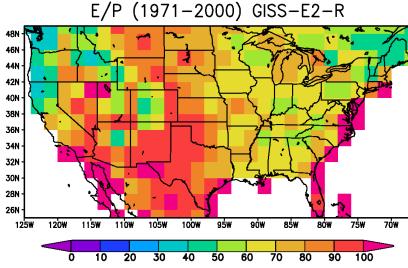
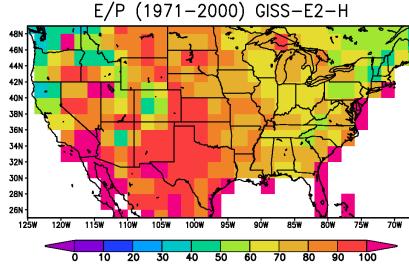
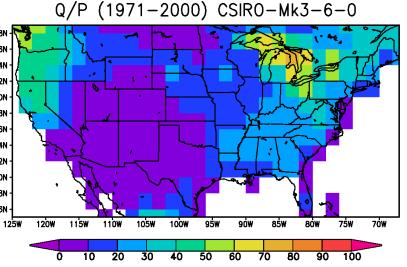
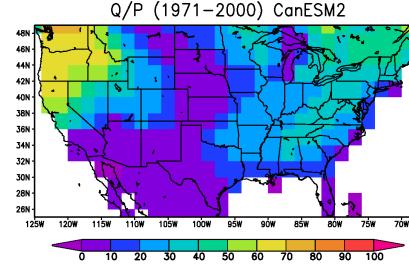
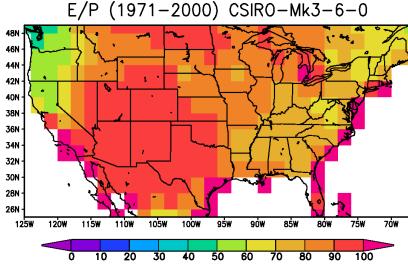
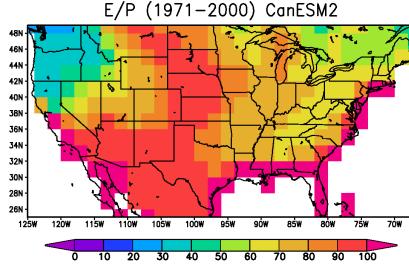
Partitioning of Precipitation into Evapotranspiration and Runoff



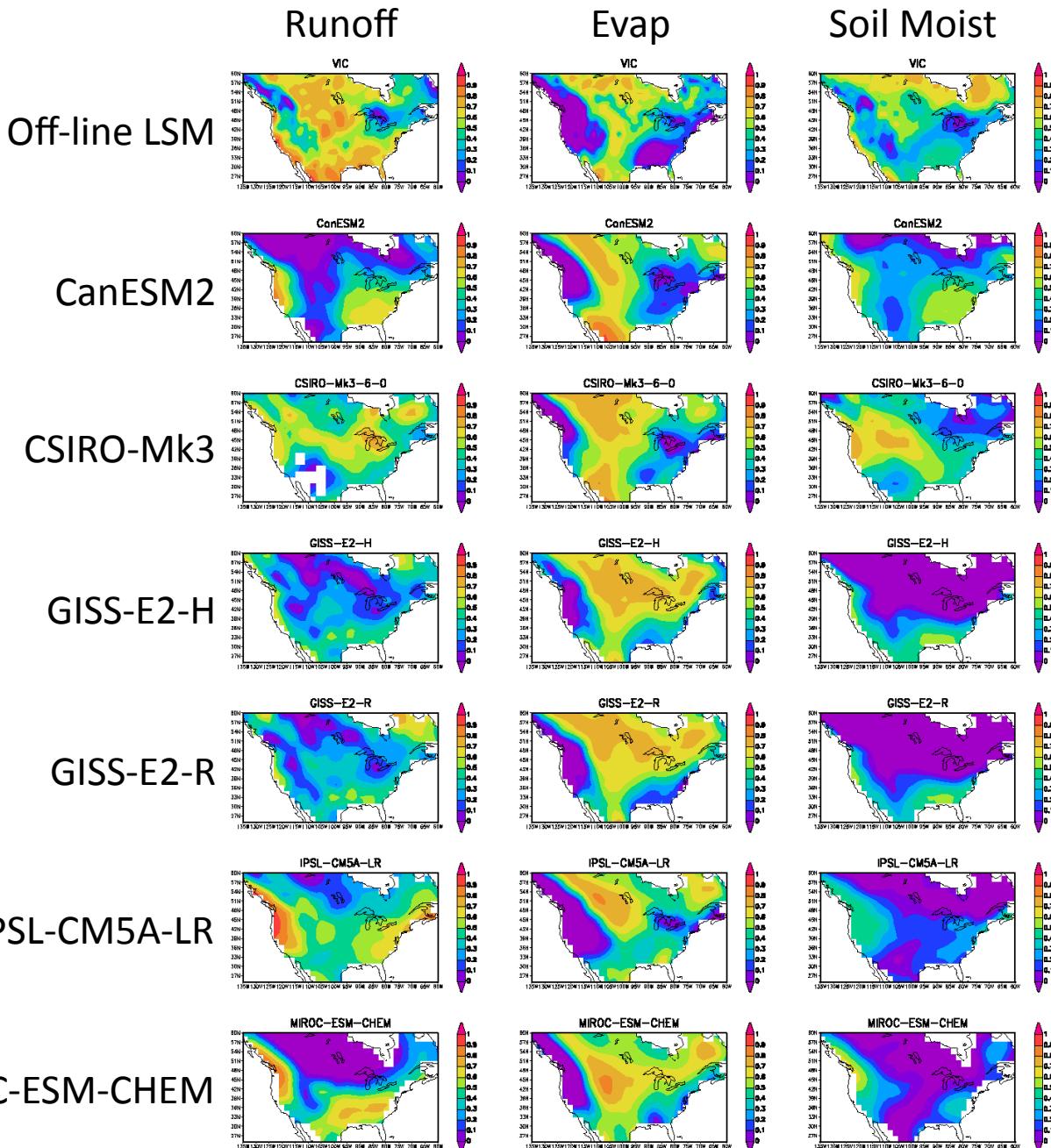
E/P



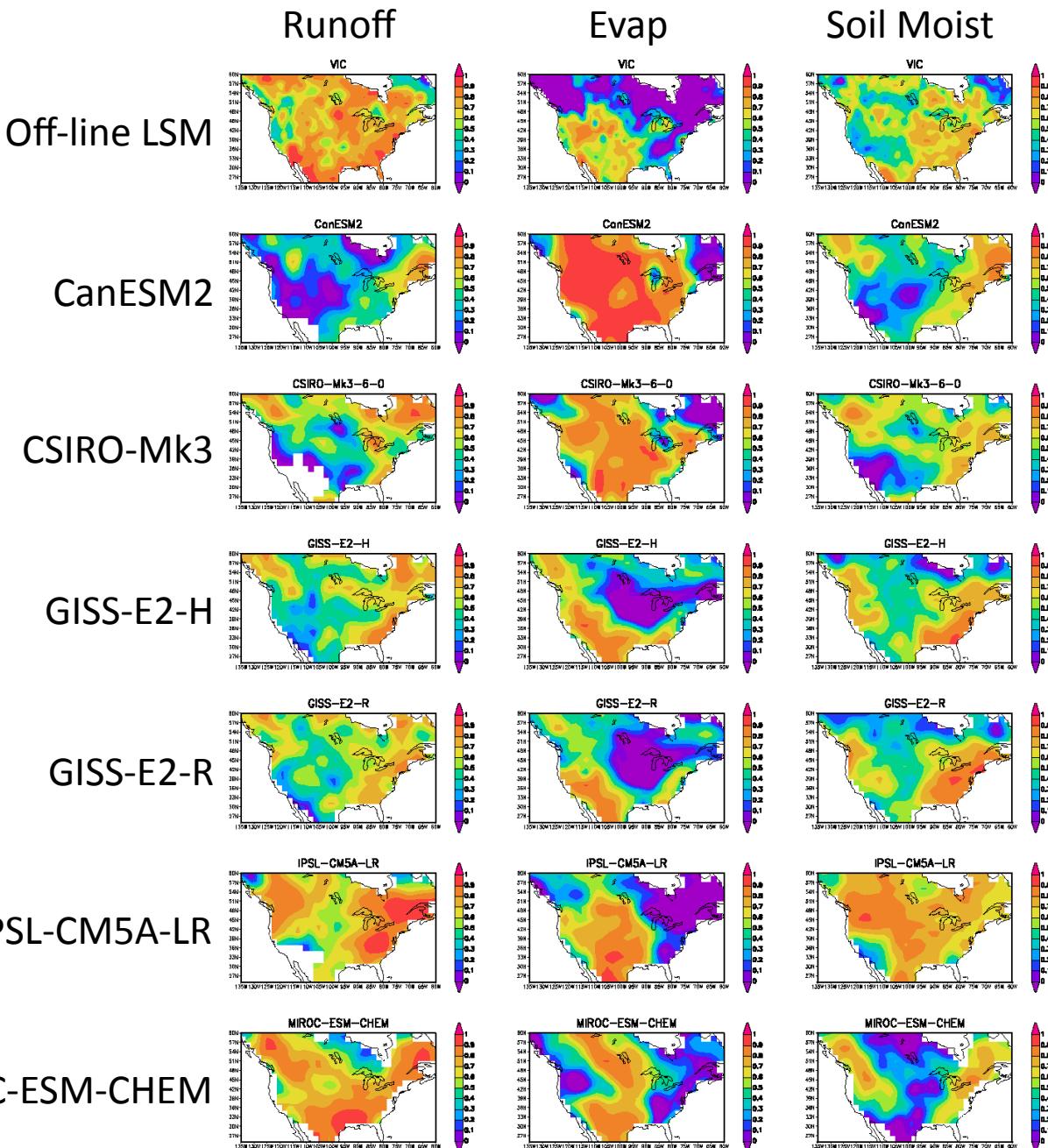
Q/P



Correlation between Precipitation and other Land Budget Components (Monthly)



Correlation between Precipitation and other Land Budget Components (JJA)



Conclusions

1. Future projections show increased drought occurrence, duration and severity, globally and particularly in many sub-tropical regions. CMIP5 results similar to CMIP3
2. Can we better quantify and reduce uncertainty in future projections based on 20C evaluations focused on physical processes?
3. CMIP5 models do a reasonable job at capturing the regional variation in drought characteristics, although with large spread across models
4. Tend to over-predict the frequency of long-term droughts, which may be due to differences in climate variability and/or land processes (e.g. soil moisture dynamics)
5. Some hint that the differences are dominated by the soil moisture physics
6. Future work:
 1. Diagnosing differences in 20th century drought characteristics among models (climate variability versus land processes)
 2. Drivers of future change: changes in P versus changes in E (complicated by seasonality)